International Journal of Sustainable and Green Energy
2015; 4(6): 212-218
Published online November 14, 2015 (http://www.sciencepublishinggroup.com/j/ijsge)
doi: 10.11648/j.ijrse.20150406.12

The Current World Energy Situation and Suggested Future Energy Scenarios to Meet the Energy Challenges by 2050 in the UK

Ahmed Gailani[1], Waleed Al-sallami[2], Nawar H. Imran[3]

[1]School of Electronic and Electrical Engineering, University of Leeds, Leeds, UK
[2]School of Mechanical Engineering, University of Leeds, Leeds, UK
[3]School of Chemical and Process Engineering, University of Leeds, Leeds, UK

Email address:
e.ahmedalheety@gmail.com (A. Fakhri)

To cite this article:
Ahmed Gailani, Waleed Al-sallami, Nawar H. Imran. The Current World Energy Situation and Suggested Future Energy Scenarios to Meet the Energy Challenges by 2050 in the UK. *International Journal of Sustainable and Green Energy*. Vol. 4, No. 6, 2015, pp. 212-218.
doi: 10.11648/j.ijrse.20150406.12

Abstract: Currently, energy demand is ever increasing along with the high levels of population world-wide. The global dependence on fossil fuels is very high and the need for reducing our energy consumption in line with mitigating the greenhouse gasses emissions is compelling. With the current global reduction of oil prices, companies or even governments tend to import more energy due to economic reasons. For instance, recently, DHL which is a famous company providing international express delivery, introduced a helicopter express delivery in London. Such development gives a real indication that as people/agencies consume more fossil fuels, in fact, the world become closer to the reserves ending point. Accordingly, this makes renewables deployment and hence reducing energy cost is quite difficult. This paper gives an overview of the current world energy situation along with three energy scenarios for the UK to achieve the official announced targets by 2050. Finally, looking for liquid metal battery advantages to secure our future energy needs.

Keywords: Liquid Metal Battery, Greenhouse Gasses, Global Energy Consumption, Energy Scenarios for the UK by 2050, DECC

1. Introduction

Global primary energy consumption is increased at an alarming rate during the last three decades. For instance, Electricity generation consumption raises from around 4000/MTOE in 1971 to ~8000/MTOE as shown in Fig.1 with expected demand growth by 37% by 2040[1, 2]. With the current continues demand growing, it is questionable if the current energy system could withstand the expected challenges: fossil fuel domination, climate change concerns, hindering the environmentally benign resources deployment along with volatile industry market prices [3]. Hence, it is worthwhile trying to predict the future energy scenarios even though the energy system itself is highly complex. As people, nowadays, take the energy for granted in line with less awareness about future energy issues, it is mandatory to publicise or predict some future energy scenarios depending on the current statistics. Therefore, in this study, three energy scenarios with respect to the UK energy system by 2050 will be presented along with assessment with regard to each energy trilemma triangle leg: energy security, cost, and carbon emissions. Then, looking to some advanced technological solutions or inventions that help to alleviate some energy challenges. Ultimately, a conclusion will be given.

2. Future Energy Scenarios

Generally, there have been three energy scenarios along the history of the human beings [3]. In the ancient ages, the population was small, and the human or animal power was used to generate the energy. Then, with the industrial revolution, the use of heat engines facilitates the energy delivery to the demands. Afterwards, with the advanced of induction motors and power electronic converters, the electrical age has begun and still continues. Accordingly, nowadays, with the current higher standard of living, the unprecedented energy consumption, along with the world population inflation, graver concerns start looming such as global warming or reserves ending points [4,5]. Hence, in this section, three scenarios for the UK will be investigated based on the following world current energy assumptions:

- The global energy generation is mostly dominated by fossil fuels with more than 83% as shown in Fig.2
- Most of the oil which is imported from the Middle Eastern countries with highly likely being in turmoil and increasingly affected by geopolitics factors, thus, in turn makes the oil prices more volatile [6,7]. For instance, in the previous months, oil prices were suddenly climbed around 6% in one day from 55$/barrel to 59$/barrel as Saudi Arabia (Top World Producer) launched air strikes upon Yemen [8].
- With the current rate of consumption, the coal is expected to last for 200 years, the oil is projected to last for 100 years while the gas is expected to last 150 years as depicted in Fig.3 [9].
- The temperature rise due to greenhouse gasses (mostly CO_2), as the big eight countries generally agreed, should not exceed 2C° with (1100 Gigatonnes) carbon emissions reduction from 2011 to 2050 [10].

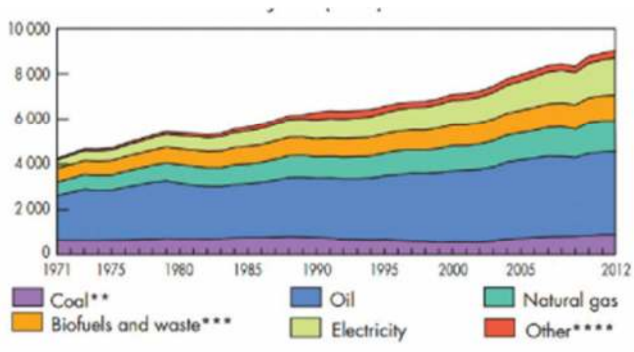


Fig. 1. World Primary Energy Consumption since 1971 until 2012 per MTOE[1].

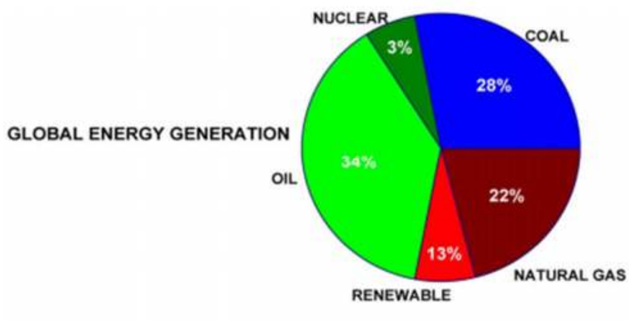


Fig. 2. Current Global Energy Generation mix [7].

Since it is quite difficult to predict the overall world scenarios due to different regional priorities, all the data and the analysis will be presented according to the UK energy system using '*The UK2050 pathway calculator'* which is a tool available online from Department of Energy and Climate change (DECC) to increase public awareness about climate change and energy security along with help policy makers and energy industry [11]. Yet, for reference guidance, the analysis has been done by taking into account the followings; transport system electrification, demand side management or energy efficiency, renewables deployment with others, and growth in industry (see Appendix A). Hence, three predicted scenarios for 2050 are shown below depending on the way of ensuring affordable cost, secure supply and abated emissions.

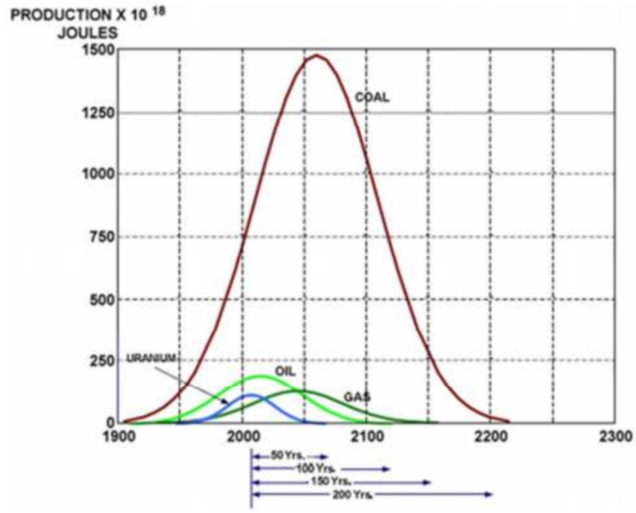


Fig. 3. The depletion curves of fossil fuels sources with Uranium (Nuclear energy) [9].

2.1. First Energy Scenario

In this scenario, a try to ensure energy supply security, low cost along with low carbon emissions, according to the UK official commitments by 2050. These commitments are to ensure most of the energy consumption is met from renewables in line with a cost reduction during time and 80% carbon reduction compared to 1990 levels [12,13]. Hence, the choices will mainly be based to solve the energy trilemma shown in Fig.4 by trying to adequately meet all the three targets despite the extreme difficulty.

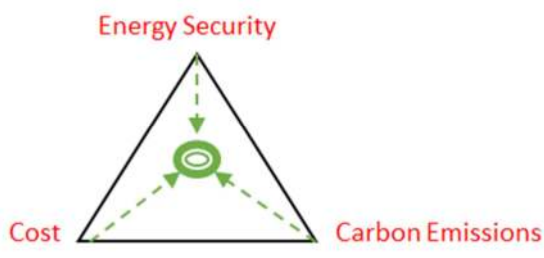


Fig. 4. Energy Trilemma represents the difficulty of meeting all three objects at the same time.

However, the constraints of approaching the three optimum targets comes from the fact of Kaya Identity [14], as follows:

$$C = P\ x\ \frac{E}{GDP}\ x\ \frac{GDP}{P}\ x\ \frac{C}{E} \quad (1)$$

Where C is the carbon emissions, P is the population, $\frac{E}{GDP}$ is the energy consumption, $\frac{GDP}{P}$ is the Gross Domestic product and $\frac{C}{E}$ is the carbon intensity of energy supply.

At first glance, reduce any of the four aforementioned factors consequently leads to reduce carbon emissions which in turn means increase renewables share and decrease fossil fuels. But reducing (P) and ($\frac{GDP}{P}$) is undesirable due to obvious reasons. Thus, reducing either ($\frac{E}{GDP}$) or ($\frac{C}{E}$) represents attractive solutions before any increase of other factors. However, firstly, reducing ($\frac{E}{GDP}$) means reducing the energy taken per GDP or 'energy efficiency' but that will not likely solve the problem entirely as it is still on the demand side management. Secondly, reducing ($\frac{C}{E}$) means decarbonizing the energy supply by using renewable energy, nuclear or carbon capture and storage (CCS). So far, this may be a good solution to alleviate the problem of energy trilemma.

However, in this scenario and with respect to the previous analysis, the main focus will be for ensuring the carbon emissions not below 80% as required and reflect the results upon the cost and supply security. Thus, the choices to effectively meet this target can be seen in (Appendix B) while the results and the analysis are shown below:

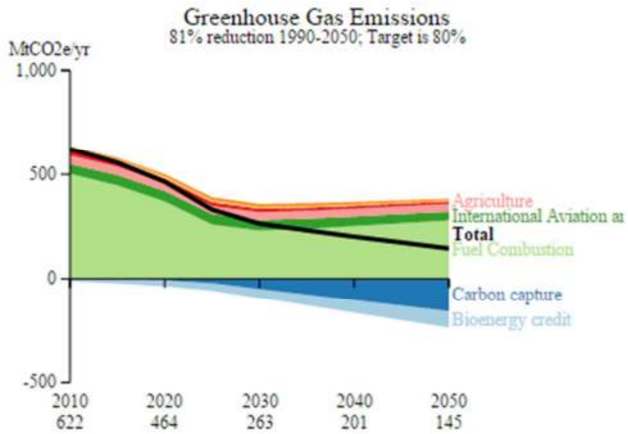


Fig. 5. *GHG emissions for UK 2050, 1st Scenario.*

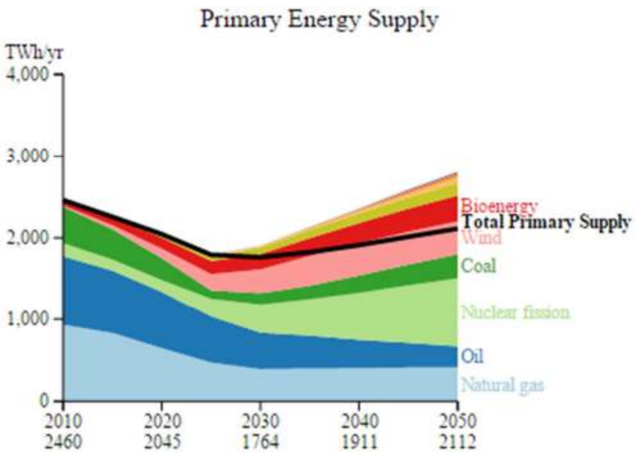


Fig. 6. *Primary Energy Supply for UK 2050, 1st Scenario.*

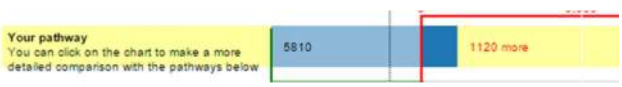


Fig. 7. *The cost required in (£/year/person), 2050, 1st S.*

It could be clearly seen from Fig.5 that the total GHG was reduced from 622 $MTCO_2$ in 2010 levels to 145 $MTCO_2$ by 2050 with 81% reduction. While Fig.6 shows the total primary supply experienced a low decrease but Bioenergy and wind are dominant instead of fossil fuels particularly oil. However, as the new technologies associated with higher cost such as offshore and Wave, the customer should pay as much more as (1120£/year/person) than they paying now as shown in Fig.7 which is more expensive.

In conclusion for this scenario, the energy trilemma is not completely solved albeit the CO_2 emissions target and supply security were achieved, due to renewables high investment cost. However, it should be noted that maintenance and operation cost of renewables is much less than fossil fuels as follows:

$$C = \frac{I}{aE} + \frac{M}{E} \tag{2}$$

Where C is the total cost of energy, I is the investment cost, E is the annual energy production, a is the discounting factor, and M is the operating cost.

2.2. Second Energy Scenario

In this scenario, the main focus is to achieve acceptable cost by increasing the energy efficiency particularly at the demand side. Hence, the choices are shown in (Appendix B) while the results and the analysis are shown below:

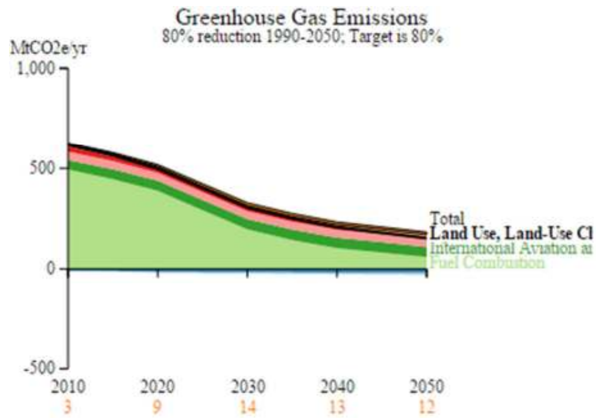


Fig. 8. *GHG emissions for UK 2050, 2nd Scenario.*

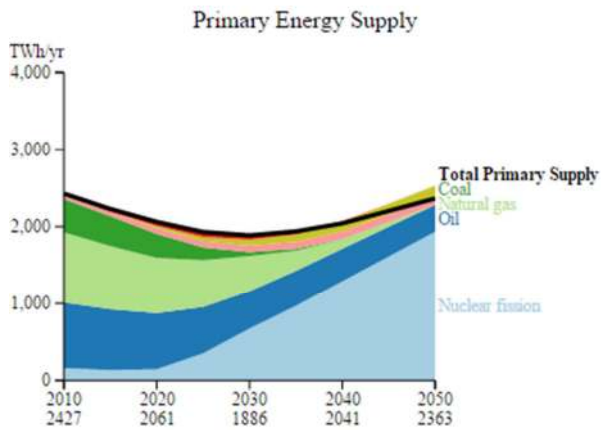


Fig. 9. *Primary Energy Supply for UK 2050, 2nd Scenario.*

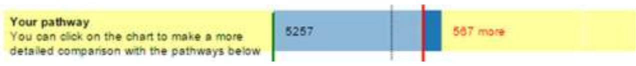


Fig. 10. *The cost required in (£/year/person), 2050, 2nd S.*

As could be seen from Fig.8, the GHGs emissions goal once again was achieved thanks to the huge efforts made on demands side management along with the tremendous industry growth. Fig.10 shows that the added energy price per person per year is £567 which is superior to the previous scenario. However, the big debate is with Fig.9 when the supply security left mostly to the nuclear power along with Coal, Oil, and Gas. Accordingly, nuclear power, indeed, is cost effective, low carbon and secure thus it solved all the energy trilemma triangle. But after Fukushima nuclear plant accident in 2011, all countries have been investigated their plants and some others already started to shut down some of these plants if not all of them [15]. Nevertheless, there are many problems associated with nuclear power to be globally scalable such as the nuclear waste, the proliferation, the Uranium resource, the accident rate and the land area [16].

In conclusion for this scenario, in our opinion, this could be the worst one as the predicted energy supply cannot withstand the expected future energy challenges. And we believe that the (DECC) made a mistake when they assigned the GHGs emissions as the ultimate goal. Because this can be achieved even if nuclear and fossil fuels being used as seen here.

2.3. Third Energy Scenario

In this scenario, the choices were selected very carefully as shown in (Appendix B) to solve the energy trilemma as adequate as possible to ensure secure, affordable and environmentally benign energy sector. The results and analysis are discerned below:

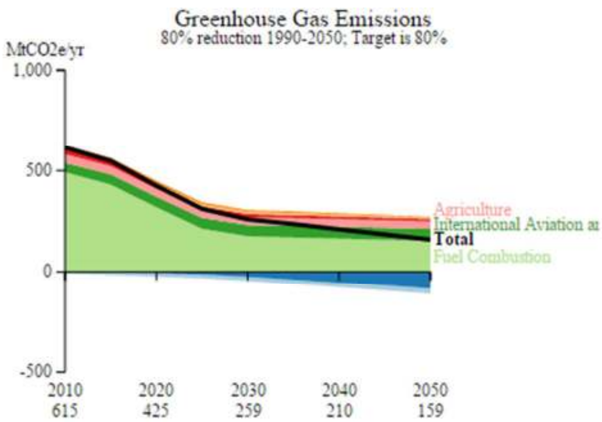


Fig. 11. *GHG emissions for UK 2050, 3rd Scenario.*

It could be seen from Fig.11, the GHGs emissions target is achieved same like the previous scenarios. The supply is dominated mainly by wind power and nuclear. Then with fossil fuels mix as depicted in Fig.12. The cost is far less than the previous scenarios with an increase of £335 per person per year as shown in Fig.13.

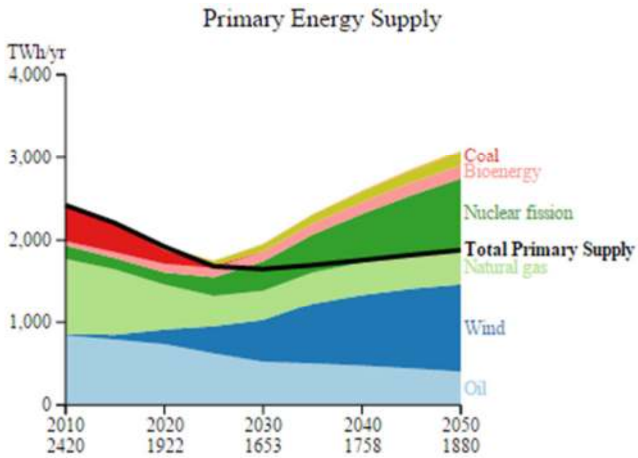


Fig. 12. *Primary Energy Supply for UK 2050, 3rd Scenario.*

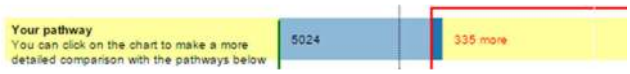


Fig. 13. *The cost required in (£/year/person), 2050, 3rd S.*

The reduced cost of energy in this path is mainly due to three reasons. Firstly, maximizing demand side management choices. Secondly, electrifying the transport system is costly because, for instance, neither electric vehicles is deployed nor it's charging infrastructure. Ultimately, reducing the cost without fossil fuels mix is difficult, at least currently, due to high investment cost related with renewables and new technologies.

3. Recent Invention: Liquid Metal Battery

One of the main constraints confronting renewable energy deployment is the intermittency of these resources. Hence, it is essential, for instance, to effectively store the energy when the sun does not shine or the wind dose not blow. Moreover, for instance, Lithium –ion battery, which is regarded the best battery nowadays is not suitable for grid-level storage as well as its high cost [17]. However, with the recent invention from MIT, liquid metal battery could play a crucial role to adequately mitigate the problem of intermittency. The battery is suitable for grid level storage with low cost, low fade rate, emissions-free, silent, made from earth abundant elements (Antimony Sb, Lithium Li, Magnesium Mg), and more effective if compared to the current battery technologies as shown in Fig.14 which represents the daily cycling of these batteries [18,19,20]. Thus, in our opinion, the use of this invention is essential for the UK as well as other nations to secure the future energy needs.

Fig. 14. *The daily cycling of number of batteries showing liquid metal battery is capable of maintaining 80% of its initial efficiency during 305 years' period [20].*

4. Conclusion

In conclusion for this paper, all global nations should agree to move by leaps and bounds to secure our energy future by meeting the demand, mitigate GHGs emissions and support renewables deployment since the dependence on fossil fuels, particularly oil is uncertain. For the UK energy future scenarios till 2050, the following points can be summarised:

- The 80% reduction of GHGs is achievable for all scenarios even if nuclear with fossil fuels are used without renewables. But this is very risky.
- The demand side management and energy efficiency is highly needed in all scenarios to achieve the future targets. Thus, increasing public awareness is necessary.
- Electrifying the transport system is also essential and the need for electric vehicles infrastructure with low cost is compelling.
- Currently, the investment cost for renewables technologies is very high. Therefore, government policies support is more likely needed along with 'angle investors', market competition to reduce the cost.
- Solving energy trilemma is difficult unless all players (Industry, public awareness, government support, global policies) agree to move in the same direction.

Ultimately, liquid metal battery is a promising battery technology for securing our energy future.

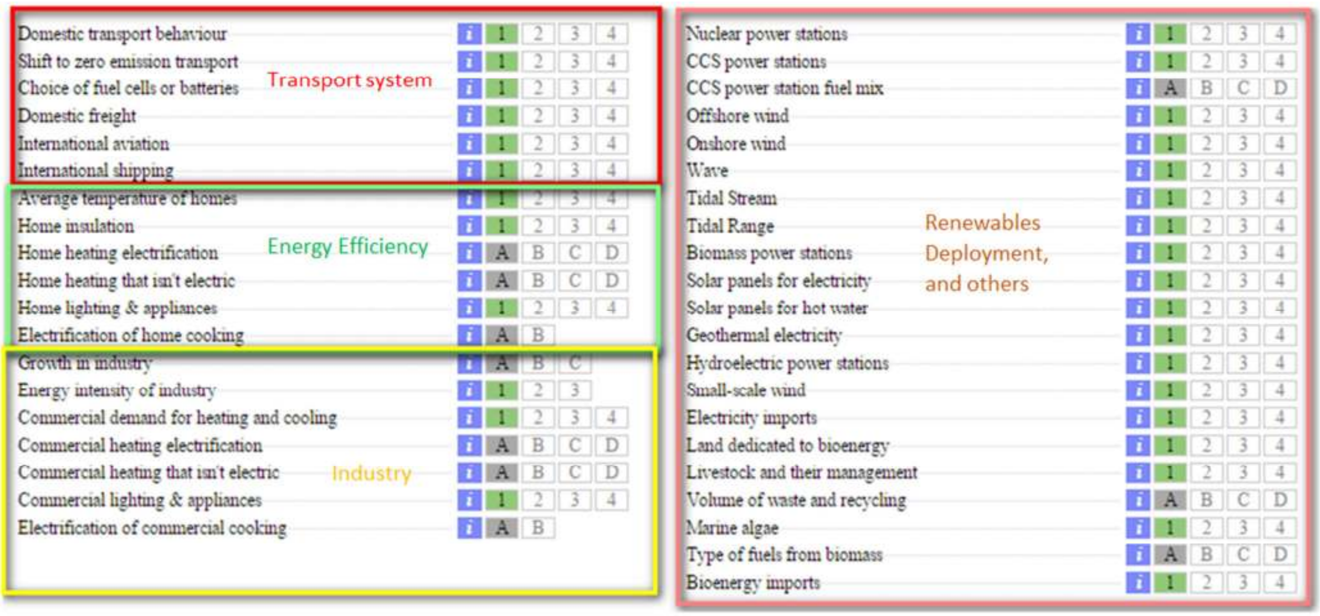
Acknowledgements

The authors would like to thank the Higher Committee for Education Development in Iraq (HCED) for providing the fund for their master's study period at University of Leeds/UK. Ahmed would like also to thank his parents (Dhaferah and Maher) for their immense support.

Appendix (A)

Refer to the website of The UK 2050 Calculator for better understanding and high quality view:
https://www.gov.uk/2050-pathways-analysis
Please note the following:

- The transition from (1) to (4) or from (A) to (D) as shown below represents the transition from the lowest case to the highest case. For example, level (1) means there is no effort to reduce emissions or save the energy while (4) means extremely ambitious target was chosen.
- For more details about the choices, because they are extremely versatile and there is no space to cover them all, please refer to the website above.
- When choosing one of any factors shown below, the results will appear immediately at the website showing the effect of the chosen indicator for supply security, CO2 emissions and the cost.

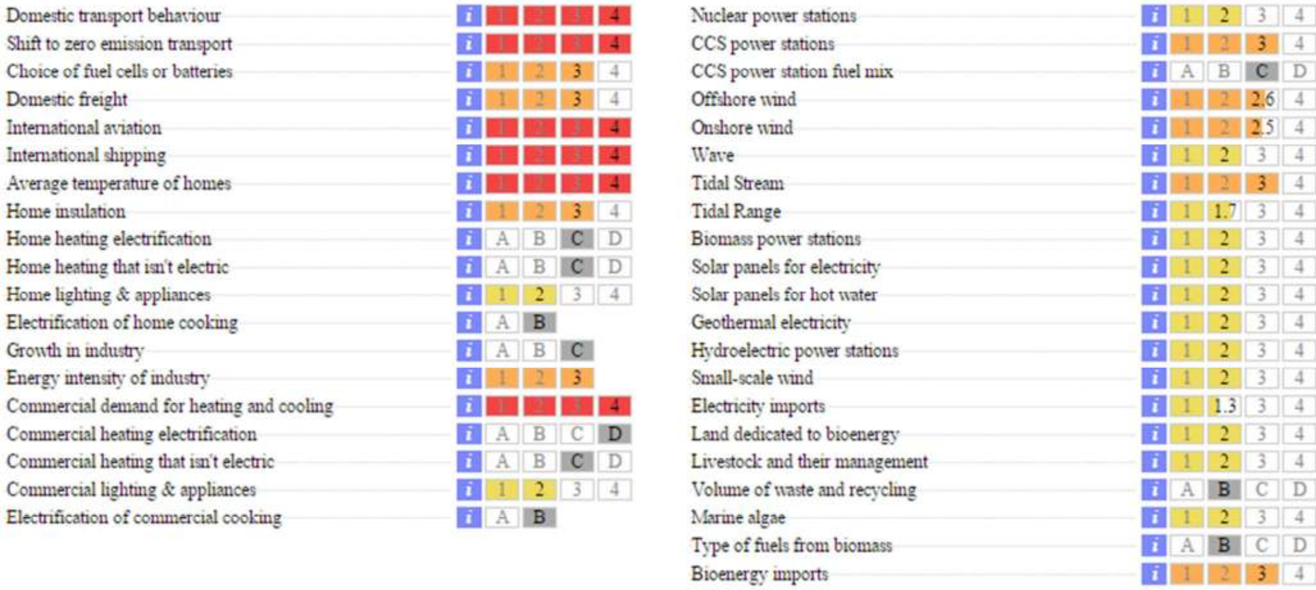


Appendix (B)

1-FIRST SCENARIO CHOICES

Choices Criteria and Analysis:

1. There is an urgent need to electrify the transport system as it is much oil based in the UK, nearly 95% of the transport system is oil based. In addition, domestic transport behavior should change to a very ambitious level as well as International shipping and aviation. Hence, the choices are shown in the first energy scenario figure below.
2. For energy efficiency, certain measures are needed to reduce the cost of energy bills. For instance, homes insulation is as high as 18m.
3. For industry choices, the main points are to fully support the growth in industry and the commercial demand of heating and cooling should be dropped.
4. For Renewables share and others, offshore, onshore wind, and CCS power stations should substantially increase to meet the demand and secure the supply along with moderate choices associated with other technologies as shown.

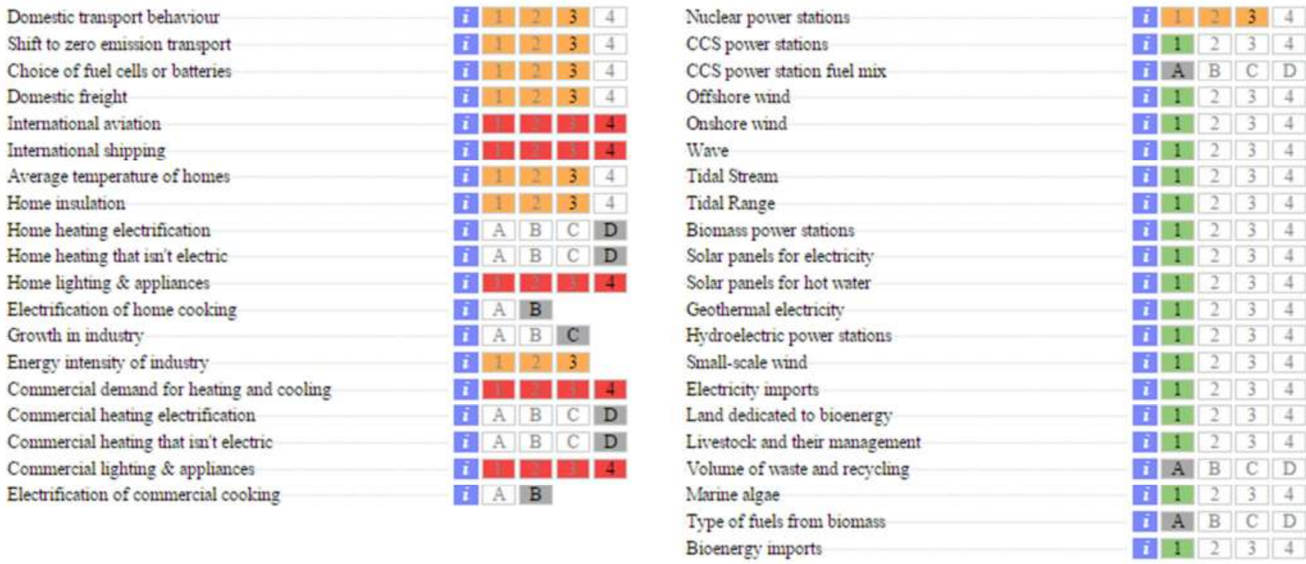


First Energy Scenario Choices Figure

2- SECOND SCENARIO CHOICES

Choices Criteria and Analysis:

1. Electrifying or decarbonizing the transport system was kept nearly the same as Scenario 1 as that is a prerequisite to achieve our future energy targets.
2. For energy efficiency, or demand side management, maximizing all the choices to the highest ambitious levels indicating full public awareness was achieved.
3. For industry choices, same like the energy efficiency, all were put to maximum.
4. Surprisingly, all renewables were set to the current limits Without any alteration. Except Nuclear power station were moved to level 3 which means more nuclear power plants need to be built.



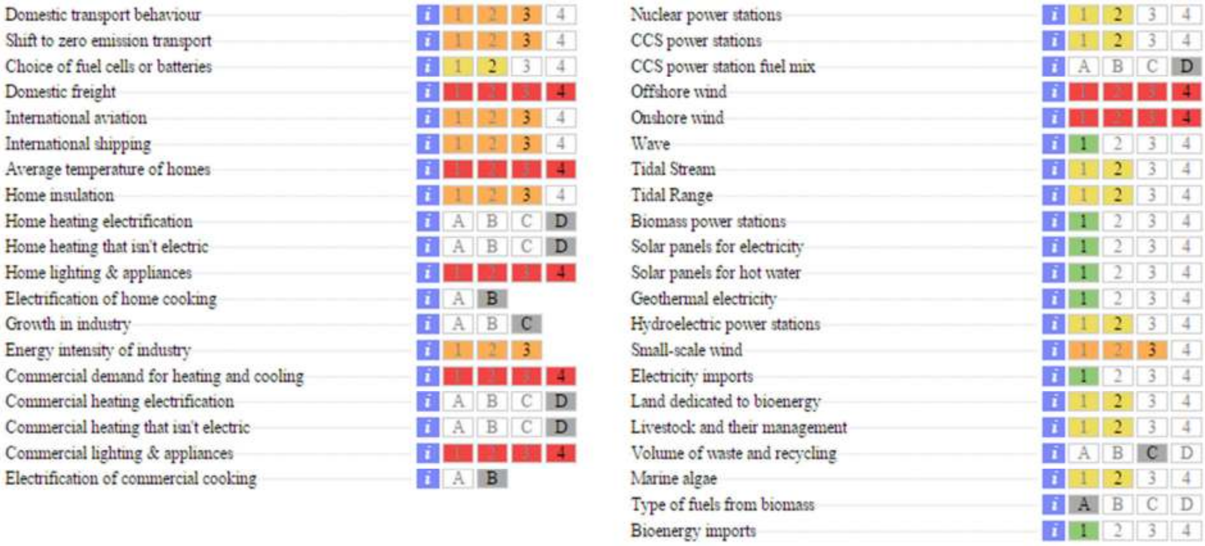
Second Energy Scenario Choices Figure

3- THIRD SCENARIO CHOICES

Choices Criteria and Analysis:

1. For the transport system, the choices were chosen to be nearly less ambitious than the second scenario due to high cost associated with deploying electric vehicles and charging infrastructure, for instance.
2. For energy efficiency, or demand side management, maximizing all the choices to the highest ambitious levels indicating full public awareness was achieved (same like 2)
3. For industry choices, same like the energy efficiency, all were put to maximum.
4. For Renewables and others, maximizing offshore wind, onshore wind, CCS, with one added nuclear plant, along

with the use of Tidal Stream and Range. This is primarily because these are promising technologies, clean, effective, albeit currently expensive. Solar was not chosen due to high cost mainly attributed to power electronic converters involved. And finally, any imports were not chosen because this can directly affect supply security.



Third Energy Scenario Choices Figure

References

[1] BP Statistical Review of World Energy. [Online]. [Accessed on 16/02/2014].Available from: http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy.html

[2] International Energy Agency (IEA). [Online]. [Accessed on 16/02/2014]. Available from: http://www.iea.org/Textbase/npsum/WEO2014SUM.pdf

[3] M. Geidl, G. Koeppel, P. Favre-Perrod, B. Klockl, G. Andersson, and K. Frohlich, "Energy hubs for the future," *Power and Energy Magazine, IEEE,* vol. 5, pp. 24-30, 2007.

[4] W. F. Pickard and D. Abbott, "Addressing the intermittency challenge: Massive energy storage in a sustainable future," *Proceedings of the IEEE,* vol. 100, p. 317, 2012.

[5] B. K. Bose, "Global warming,"*IEEE Ind. Electron*. Mag., vol. 4, no. 1, pp. 1–[2]17, Mar. 2010.

[6] World Energy Outlook.[Online].[Accessed on 18/02/2015].Available from: http://www.worldenergyoutlook.org/pressmedia/quotes/6/

[7] B. K. Bose, "Global Energy Scenario and Impact of Power Electronics in 21st Century," *Industrial Electronics, IEEE Transactions on,* vol. 60, pp. 2638-2651, 2013.

[8] BBC New (26 March 2015). [Online]. [Accessed on 30/03/2015].Available from: http://www.bbc.co.uk/news/business-32062571

[9] J. R. Roth, *Long Term Global Energy Issues in Industrial Plasma Engineering*, vol. 1. Philadelphia, PA: Institute of Physics, 1995.

[10] C. McGlade and P. Ekins, "The geographical distribution of fossil fuels unused when limiting global warming to 2 [deg] C," *Nature,* vol. 517, pp. 187-190, 01/08/print 2015.

[11] 2050 Pathways analysis report. DECC. Available from: https://www.gov.uk/2050-pathways-analysis#creating-your-pathway

[12] UK government. 2050 Pathways Analysis. 2010. [Online]. Available from: https://www.gov.uk//government/uploads/system/uploads/attachment_data/file/42562/216-2050-pathways-analysis-report.pdf

[13] P. Allen and T. Chatterton, "Carbon reduction scenarios for 2050: An explorative analysis of public preferences," Energy Policy, vol. 63, pp. 796-808, 12// 2013.

[14] Y. Kaya and K. Yokobori, Environment, Energy and Economy; Strategies for Sustainability: United Nations University Press, 1997.

[15] H. Altomonte, "Japan's Nuclear Disaster: Its Impact on Electric Power Generation Worldwide [In My View]," Power and Energy Magazine, IEEE, vol. 10, pp. 96-94, 2012.

[16] D. Abbott, "Is Nuclear Power Globally Scalable? [Point of View]," Proceedings of the IEEE, vol. 99, pp. 1611-1617, 2011.

[17] D. Larcher and J. M. Tarascon, "Towards greener and more sustainable batteries for electrical energy storage," Nature Chemistry, vol. 7, pp. 19-29, 01//print 2015.

[18] Bradwell, D.J., et al., Magnesium–Antimony Liquid Metal Battery for Stationary Energy Storage. Journal of the American Chemical Society, 2012. 134(4):p. 1895-1897

[19] Wang, K., et al., Lithium-antimony-lead liquid metal battery for grid-level energy storage. Nature, 2014.

[20] Energy 2064 Video with Professor Donald R. Sadoway. [Online]. OCT 2014. [Accessed 07/04/2015].